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[54] **TOBACCO SMOKE FILTER**

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[63] Continuation of Ser. No. 22,068, March 23, 1970, abandoned.

[52] **U.S. Cl.** **131/269**

[51] **Int. Cl.** **A24d 1/04**

[58] **Field of Search** ..... 131/269, 10.5, 10.7; 260/2.5 N; 55/522, 528

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[57] **ABSTRACT**

A tobacco smoke filter element is disclosed which is designed to be accommodated in a cigarette, cigarette holder or the stem of a pipe and which is made of foamed, open cell nylon 6.

The filter is made in rod form, has a skin of non-foamed nylon, a density of 1–5 pounds per cubic foot, a hardness of 75–95%, a resilience of 90–100% and a pressure drop across a 15mm length at a flow rate of 1500cc/mm. of between 2 and 8 centimeters of water gauge.

2 Claims, No Drawings

TOBACCO SMOKE FILTER

This is a continuation of application Ser. No. 22,068, filed Mar. 23, 1970 now abandoned.

This invention relates to filtering elements, and particularly smoke-filtering elements adapted for use with smoking devices such as a cigarette or pipe. It also includes certain new filtering elements of general application.

It has already been proposed to insert a filtering element in the end of a cigarette in order to prevent flakes of tobacco from entering the mouth and to reduce the consumption by the smoker of certain undesirable substances present in the smoke. Similarly, it has been proposed to place a filtering element in the stem of a pipe to reduce the entry of unwanted combustion products into the respiratory tract. A disadvantage of such proposals has been that filters efficient enough to have a useful absorptive effect comprise a relatively large amount of material, that is to say they have a high density, so that they are quite expensive when made by the million. Moreover, when filtering elements are made on this scale their manufacture must be rapid and convenient. Thus the production of the filtering element should involve a minimum number of steps before each filtering element is ready to be incorporated in the smoking device.

A process has now been developed which can conveniently be used to make smoke-filtering elements on a large scale. Also the smoke-filtering elements produced by the process show a useful absorptive effect at relatively low densities.

The process is one for the production of a smoke-filtering element having a cross-section suitable for use with a smoking device such as a cigarette, cigarette holder, or pipe, which comprises extruding a rod of foamed synthetic polyamide resin having a substantially open-cell structure, the rod having a transverse cross-section substantially corresponding to that desired in the final element.

The smoke-filtering elements of the invention are preferably cut or otherwise divided from a rod having an outer skin. They can be cut into pieces that are the length of an individual filter or for example, into pieces that are a simple multiple of this length, preferably from 2 to 10 times the length of an individual filter.

According to another aspect of the invention there is provided a filtering element which comprises a foamed nylon 6 (polycaprolactam) having a substantially open-cell structure.

The synthetic polyamide is a thermoplastic resin material containing amide groups as part of the polymer chain of the resin molecule It can for example be produced by the polycondensation of a diamine and a dicarboxylic acid, or of a salt of such an amine and such an acid, by the self-polycondensation of an -aminocarboxylic acid or by the polymerization of a lactam. Examples of well-known polyamides are nylon 6 (polycaprolactam), nylon 66 (polyhexamethyleneadipamide, normally produced by the self-polycondensation of the salt of hexamethylenediamine and adipic acid known as "nylon 11), nylon 11 (poly-11-aminoundecylenic acid) and nylon 610 (polyhexamethylene-sebacamide); and blends of these polyamides can, of course also be used. The preferred polyamide is nylon 6. Preferably the molecular weight of the polyamide is between 10,000 and 20,000 for example from 12,000 to 15,000.

The polyamide is in the form of a foam having a substantially open-cell structure, that is to say, at least 50% of the cells of the foam intercommunicate with neighboring cells. Preferably at least 60% of the cells are "open" in this way, and since in practice it is difficult to make a foamed nylon in which more than 95% of the cells are open the preferred range is 60–95%, and very often from 70 to 90%. Preferably most of the cells have a diameter within the range 0.002 to 0.02 inch, more preferably from 0.005 to 0.01 inch.

The density of the foam is preferably low, usually not more than 10 pounds per cubic foot and preferably from 1 to 5 pounds per cubic foot. Between 2 and 3 pounds per cubic foot is often a very suitable density.

Two important properties, particularly where the element is intended for use as a cigarette filter-tip, are the hardness and resilience of the foam. These can be measured by means of an Instron compression testing machine, applying a progressively increasing load to a cylindrical sample 15 millimeters long and 8 millimeters in diameter, the load being applied to opposite sides of the cylindrical surface by flat steel platens advanced towards each other at a relative speed of 0.2 inches per minute. The hardness is the diameter of the sample measured at a load of 300 grams and expressed as a percentage of the original diameter, while the resilience, similarly expressed, is the diameter of the sample after the load has been released for several seconds.

Preferably the hardness is from 50 to 95%, more preferably from 75 to 95% and very often from 80 to 90%.

Preferably the resilience as measured by the above test is from 80 to 100%, more preferably from 90 to 100% and very often from 98 to 100%.

For use in a cigarette, the smoke-filtering element is preferably cylindrical in shape and of the same diameter as a cigarette and for example about 0.374 to 0.75 inch in length although other shapes and sizes can optionally be used. For example, for use in a Turkish cigarette, the element would be of oval cross-section. For use in a pipe, the smoke filtering element is preferably cylindrical if required to fit in the stem, although other shapes can be used if desired.

The pressure drop across the smoke-filtering element is preferably low, for example below 15 centimeters of water gauge measured for a sample 15 millimeters in length, at a flow rate of 1500 cubic centimeters per minute. A particularly acceptable range of pressure drop is between 2 and 10 centimeters of water.

The foamed polyamide is produced by an extrusion method which allows the properties and dimensions of the rod, and hence the smoke-filtering elements cut from it, to be carefully controlled. The shape and size of the die orifice are a determining factor, and these are chosen so as to give the desired product. For example, filtering-elements incorporated in cigarettes are usually of circular cross-section and can be cut from a cylindrical rod of foamed resin extruded from a circular die orifice. Finer control of the diameter of the rod can sometimes be obtained by drawing it, although, of course, the drawing should not be such as to destroy the desirable properties of the foamed resin. The extruded rod is preferably given a hard outer skin which makes the filtering-elements cut from the rod more durable. It can be seen that the process of the invention is a simple one

giving filtering elements ready for direct incorporation into the smoking device. Unlike some conventional methods there is no need to use adhesive in forming the filtering element into an appropriate shpae or to use material in the form of a tightly rolled cylinder.

In the process of making the foamed filter one needs to employ a blowing agent, which can be a gas or vapor under normal atmospheric conditions but is preferably a volatile liquid. Preferably it possesses an appreciable solubility in the polyamide under conditions of elevated pressure and temperature such as those present in an extruder. The preferred blowing agents are lower alcohols such as methanol, ethanol and the propanols, but other examples are lower ketones, for example acetone, and lower hydrocarbons such as butane, pentane or isobutylene. If a hydrocarbon is used, a volatile plasticizer, for example methanol, is preferably also present.

The blowing agent can also be a chemical blowing agent, which can for example be a bicarbonate such as for example sodium bicarbonate or ammonium bicarbonate, or an organic nitrogen compound that yields nitrogen on heating, such as for example dinitrosopentamethylenediamine or barium azodicarboxylate. From 3 to 30% especially from 7 to 20% by weight based on the weight of the resin is often a suitable proportion of blowing agent.

Preferably the blowing agent is employed in conjunction with a nucleating agent, which assists in the formation of a large number of fine cells. A wide range of nucleating agents can be employed, including finely divided inert solids such as for example talc, silica or alumina (if desired in conjunction with an adhesive substance such as polyethylene glycol or a mineral oil), or small quantities of a substance that decomposes at the extrusion temperature to give a gas can be used. An example of the latter class of nucleating agents is sodium bicarbonate, if desired in conjunction with a weak acid such as for example tartaric or citric acid. A small proportion of the nucleating agent, for example up to 5% by weight of the resin, is usually effective. Often the amount of nucleating agent employed is in the range of from 0.1 to 5% by weight, preferably from 1 to 2% by weight.

The extrusion temperature (that is the temperature of the die and the resin within it) needs to be below the crystalline melting point of the polyamide (making a suitable allowance for the depressant effect of the blowing agent), and is preferably between 180°C. and 250°C. An extrusion temperature from 190°C. to 210°C. is often suitable for nylon 6 while 200°C. to 240°C. is often suitable for nylon 66. Higher temperatures, for example up to 300°C., can exist in the extruder barrel, particularly where the blowing agent is directly injected into the molten polyamide. For example a barrel temperature of 220°C. to 250°C. is often suitable for nylon 6, while for nylon 66 a barrel temperature of 265°C. to 280°C. is more suitable.

Production of the requisite open-cell structure can be ensured by suitable choice of extrusion conditions. For example the surface of the extruding foam can be cooled or the temperature of the extruding material controlled so as to form a surface skin strong enough to prevent collapse as the pressure within the cells falls. The cells walls become perforated during the foaming process and this is assisted by the relatively high fluidity of the polyamide when plasticized with blowing agent. A nucleating agent can also assist in cell-wall rupture and for example a mixture of talc and polyethylene glycol has been found to be particularly useful in this respect.

As described above, the invention includes a filtering element which comprises a foamed nylon 6 (polycaprolactam) having a substantially open-cell structure.

The foamed nylon 6 can be produced by molding or by extrusion methods (referred to above). When a molding method is used the products can be directly molded in the desired shape so that there is no need for further treatment, or it can be cut or otherwise divided into pieces, such as strips, to give a filtering element of appropriate shape and properties.

The foamed nylon 6 can also be produced by extrusion techniques. It is often convenient to extrude the foamed nylon 6 in the form of a rod which can then be cut or otherwise divided into pieces of the desired length. Thus a preferred filtering element is in the form of a rod of foamed nylon.

The nylon 6 filtering elements are applicable to general filtration, for example air conditioning, central heating, mining, oil or water filtration, and so on. They are particularly useful in filtering entrained dust particles from streams of air or other gases, and can, for instance, be employed as smoke-filtering elements.

One preferred form of filtering element comprises a number of rods or strips of foamed nylon 6 packed together in parallel arrangement. Such filtering elements find many industrial applications for each of which a filtering element having appropriate properties can be built up. For example the rate of filtration of the filtering element party depends on the cross-sectional area of the element and this can be varied according to the number of rods of foamed nylon 6 packed together. In addition the filtering action is controlled by the length of the rods employed; the longer the rods, the more efficient the filtering action. However, a practical limitation is put on the length of the rods by the need, in many cases, to reduce the pressure drop across the filtering element to a sufficiently low value.

The rods of foamed nylon 6 are preferably packed together in a matrix, for example an adhesive, or by exerting pressure on the packed rods so that air gaps between them are excluded.

This invention is illustrated by the following Examples.

EXAMPLE I

This Example describes a process for producing a cigarette-filter element. All parts are by weight.

A blend of 100 parts of nylon 6, 0.1 part of polyethylene glycol and 2 parts of finely-divided talc was fed to an extruder fitten with a circular orifice die of diameter 1/16 inch and land 3/16 inch. 16.5 Parts of methanol were injected into the molten nylon at a temperature of 278°C. and the resulting mixture was cooled as it passed along the extruder barrel, the extrusion temperature being 193.5°C.

There was extruded a rod of foamed nylon, of overall density 2.5 pounds per cubic foot, about 0.25 inch in diameter, having an outer impervious skin enclosing a mass of intercommunicating open cells of average diameter 0.009 inch. About 70 to 80% of the cells were open. The foam had 86% hardness and 99% resilience as measured by the test described above.

The rod was chopped up into pieces about 0.7 inch long and there were used as filter tips for cigarettes. When the cigarettes were smoked, it was found that the tips had a pleasing resilience and did not have any adverse effects on the smoke's taste. Neither did they offer a detectable resistance to the flow of smoke. When the elements were later cut up they were found to have removed a considerable quantity of tar from the smoke, comparable with that removed by a conventional cellulose acetate tow filter having a density 9.75 pounds per cubic foot.

EXAMPLE II

This Example describes a filtering element according to the invention.

A rod of foamed nylon 6 having the properties described in Example I and produced by the process described in that Example, was chopped into pieces 4 inches long. Adhesive was applied to that outer skin of 80 such rods and they were packed together in parallel arrangement. A slight pressure was applied to ensure good adhesive contact and to exclude air gaps and channels between the rods.

The filtering element so formed showed a pressure drop across its ends of 65.3 centimeters of water, as measured by a water manometer at an air flow rate of 1500 cubic centimeters per minute. The filtering element was tested for its properties of extracting tar from cigarette smoke and these were found to be excellent.

What is claimed is:

1. An improved foamed open cell tobacco smoke filtering element the improvement comprising, foamed Nylon 6 having from 60 to 95% open perforated cell structure, a density of from 1 to 5 pounds per cubic foot and said cells having a diameter of about 0.002 to about 0.02 inch, said filtering element having the form of an extruded rod having an impervious substantially nonfoamed Nylon 6 skin and traverse cross-section substantially corresponding to the final element and which coresponds to the diameter of the cigarette, the cigarette holder or the stem of a pipe in which it is to be fitted and the hardness of the rod is from 75 to 95%, the resilence of the rod is from 90 to **100**% and the pressure drop across said rod about 15 millimeters in length at a flow rate of 1500 cubic centimeters per minute is between 2 and 8 centimeters of water gauge providing low resistance to the flow of smoke through the filter element.

2. A smoking device comprising the smoke filtering element of claim **1.**

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